Aerial Spray Plume Dispersion Measured With Lidar

David Miller, University of Connecticut

April Hiscox, University of Connecticut

James Ross, New Mexico State University

Carmen Nappo, NOAA, ATTDD

Project Objectives

- Quantify Aerial Spray Plume Characteristics and Dynamics for:
  - Small size distribution sprays – Vector control
  - Calm Stable Conditions

Spray Application

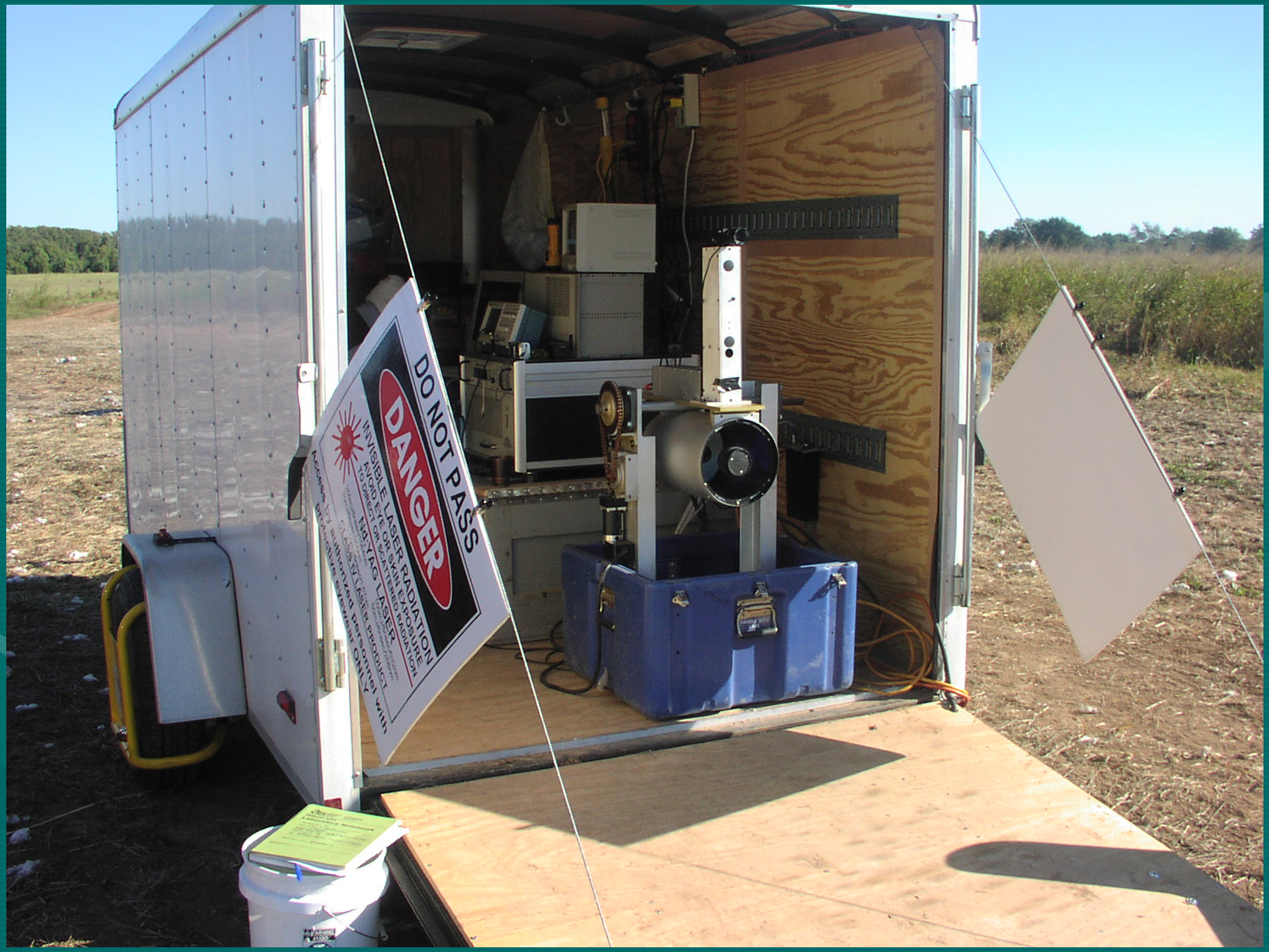
- Aircraft: Cessna T188C
- Atomizers: Micronaire AU5000 rotary atomizers
- Spray solution: water with 9% vegetable oil and 1% adjuvant
- DV0.1 = 13.3μ, VMD = 37.3μ, DV0.9 = 82.8μ
- Application rate: 21.6 gallons / acre

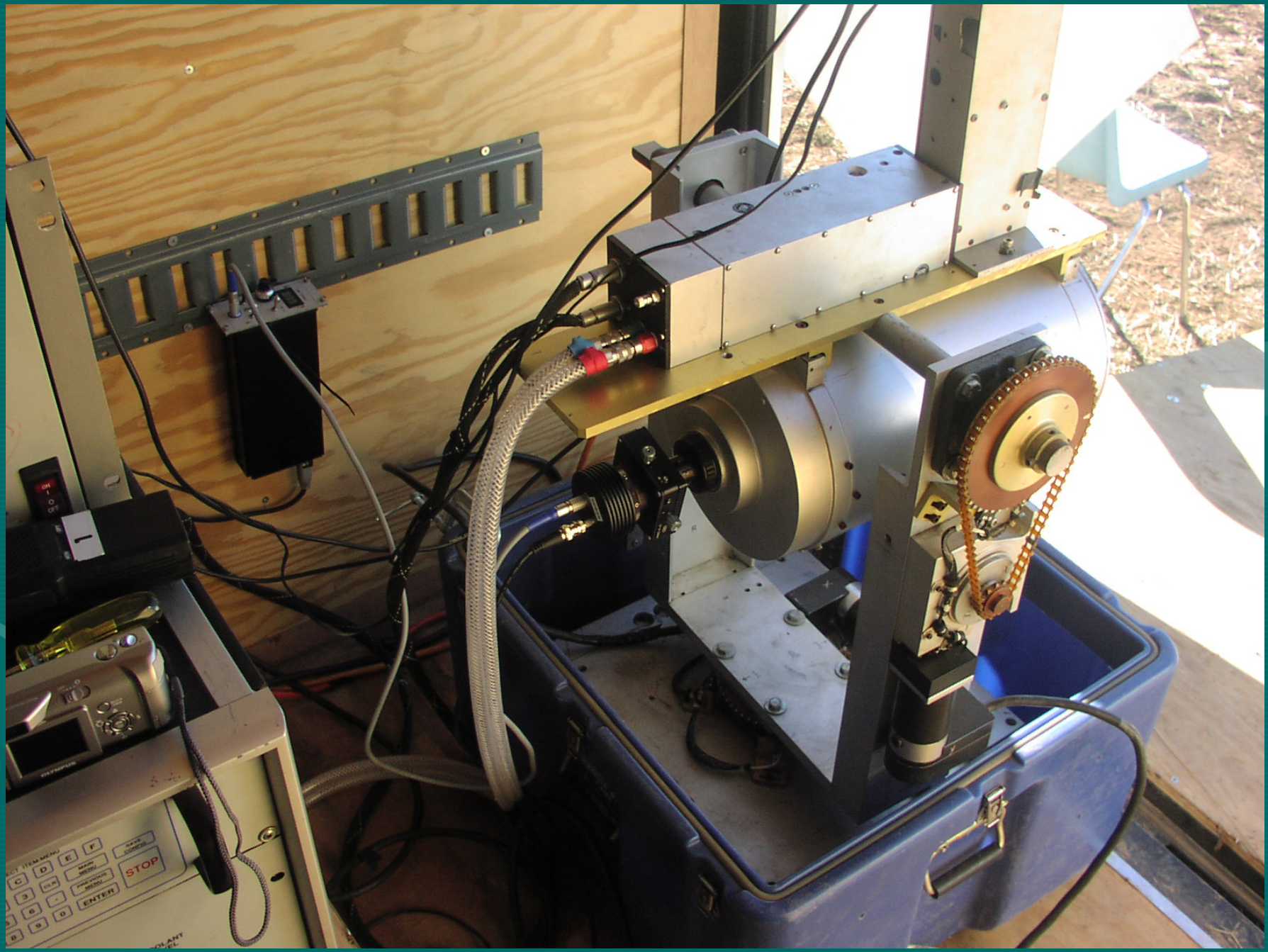
Enterprise
van

3-D Sonic Anemometer

Meteorological Conditions at the Spray Height During Single Spray Passes

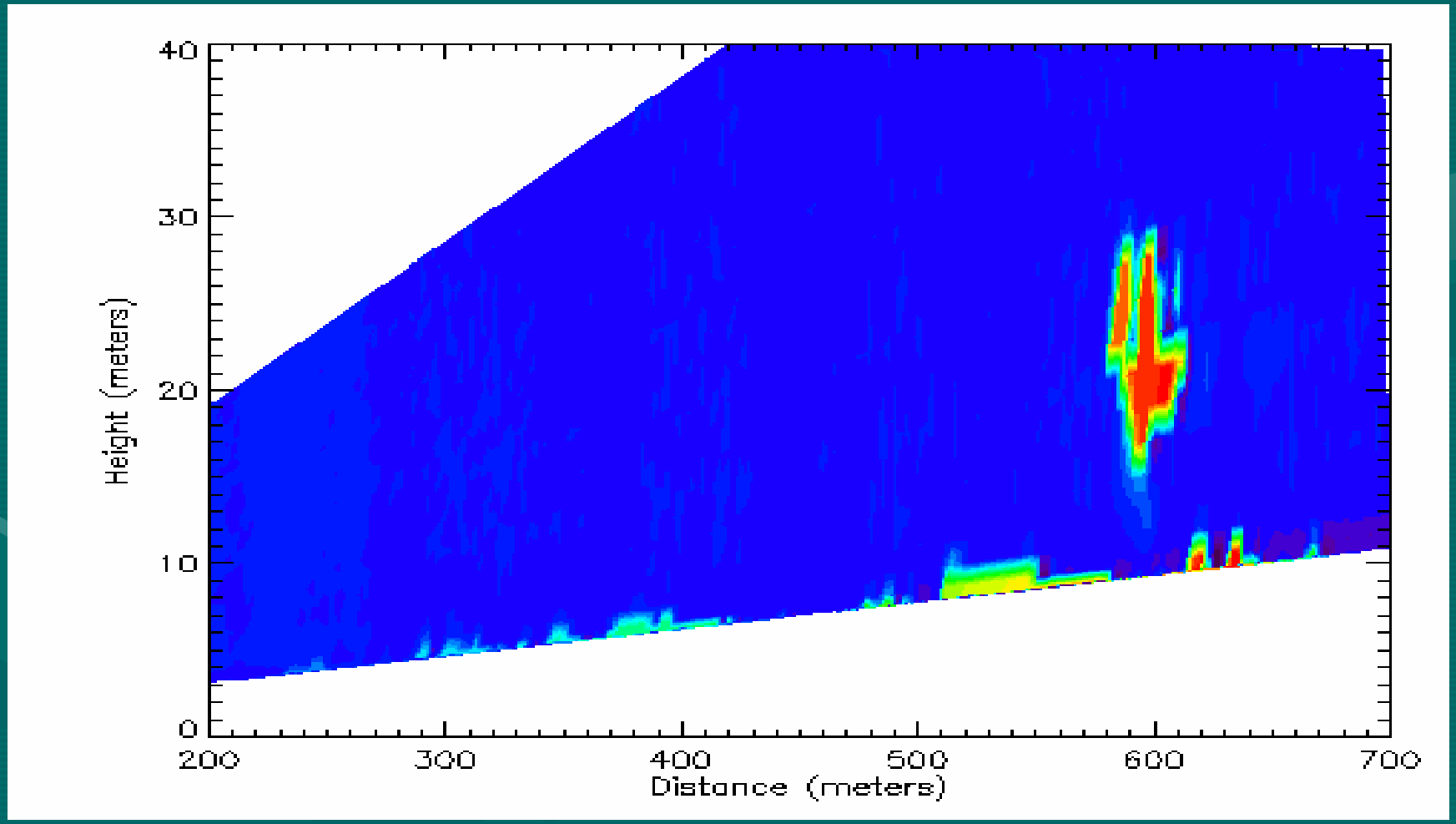
	Pass 1	Pass 2	Pass 3	Pass 4	Pass 5
Time	6:17:47	6:24:51	6:50:54	6:56:59	7:04:09
U (m/s)	1.44	0.83	1.99	1.63	2.21
Udir (deg)	32	46	71	60	58
ζ (stability)	126.5	36.0	2 0.5	185.8	-28.5
T (C)	8.5	8.9	9.2	9.4	9.7
RH (%)	74	74	57	52	49


DO NOT PASS
DANGER
INVISIBLE LASER RADIATION
AVOID EYE OR SKIN EXPOSURE
TO DIRECT OR SCATTERED RADIATION
MOTAG LASER

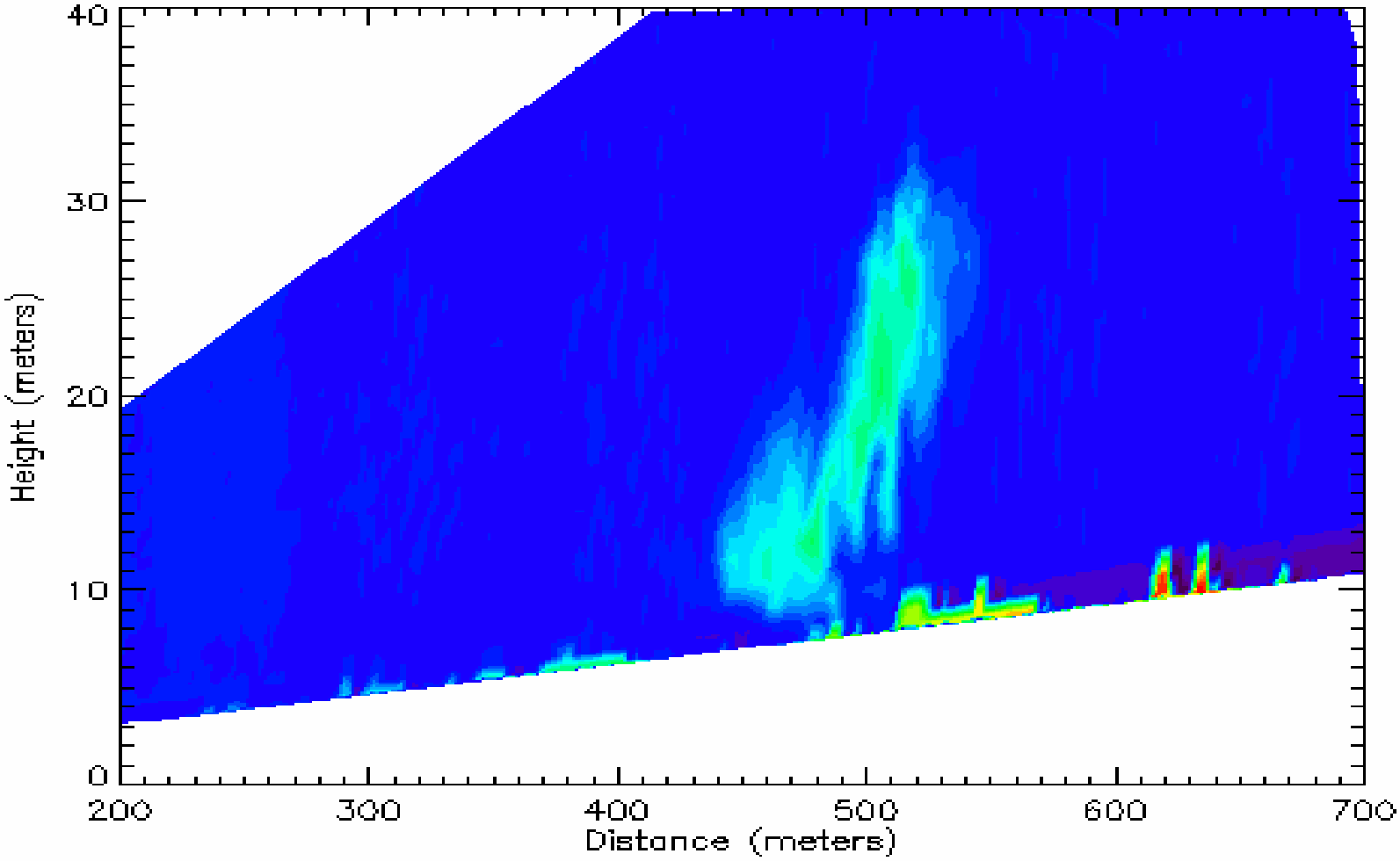

STOP
ENTER

UNIDEX 14

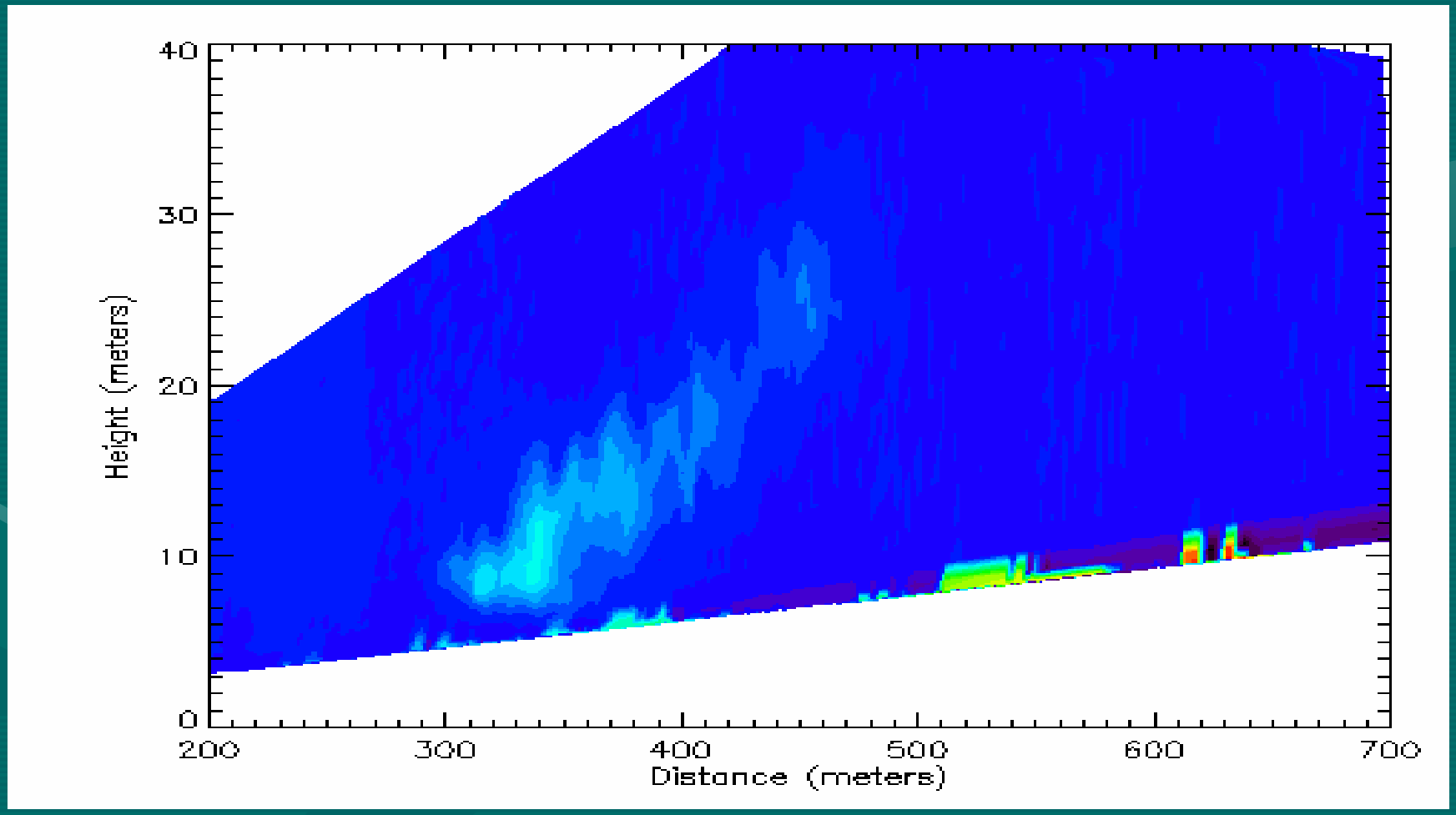
Slice Through Plume 3 seconds after Spray Release

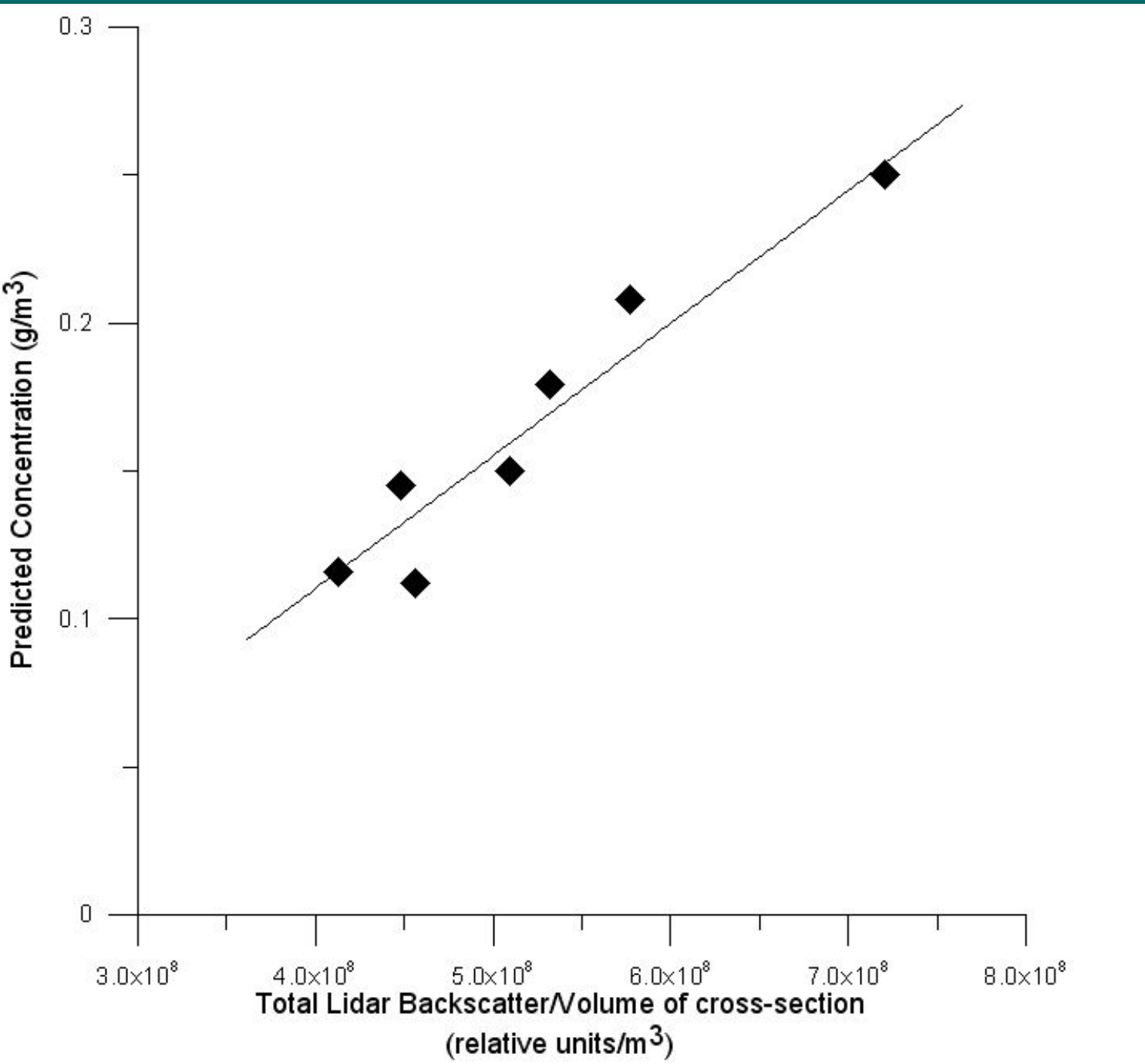


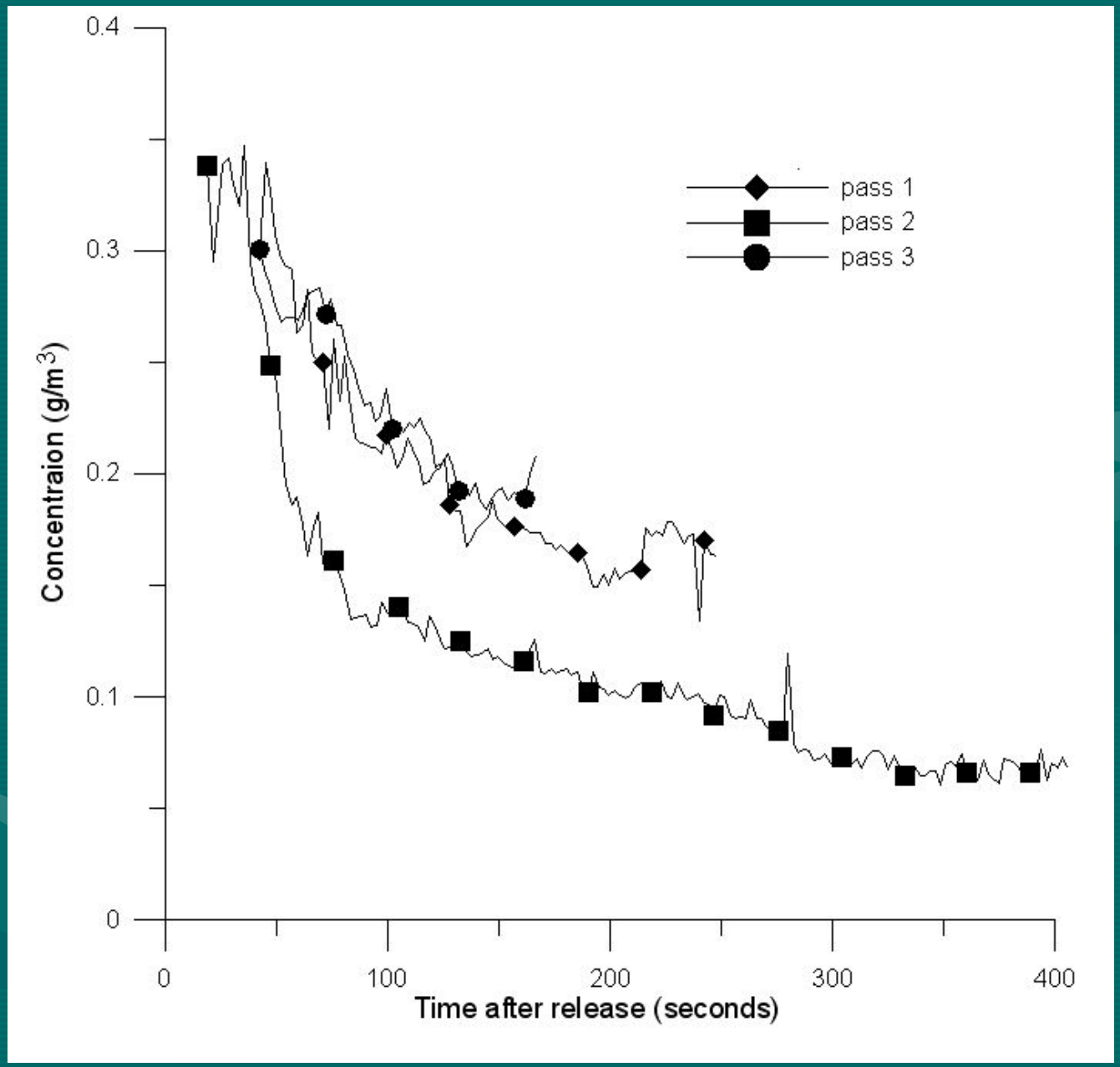
Plume Cross Section and Location after 2.5 Minutes



Plume Cross Section and Location after 5 Minutes




0.3
0.2
0.1
0
Predicted Concentration (g/m3)
3.0x10^8
4.0x10^8
5.0x10^8
6.0x10^8
7.0x10^8
8.0x10^8
Total Lidar Backscatter/Volume of cross-section
(relative units/m3)

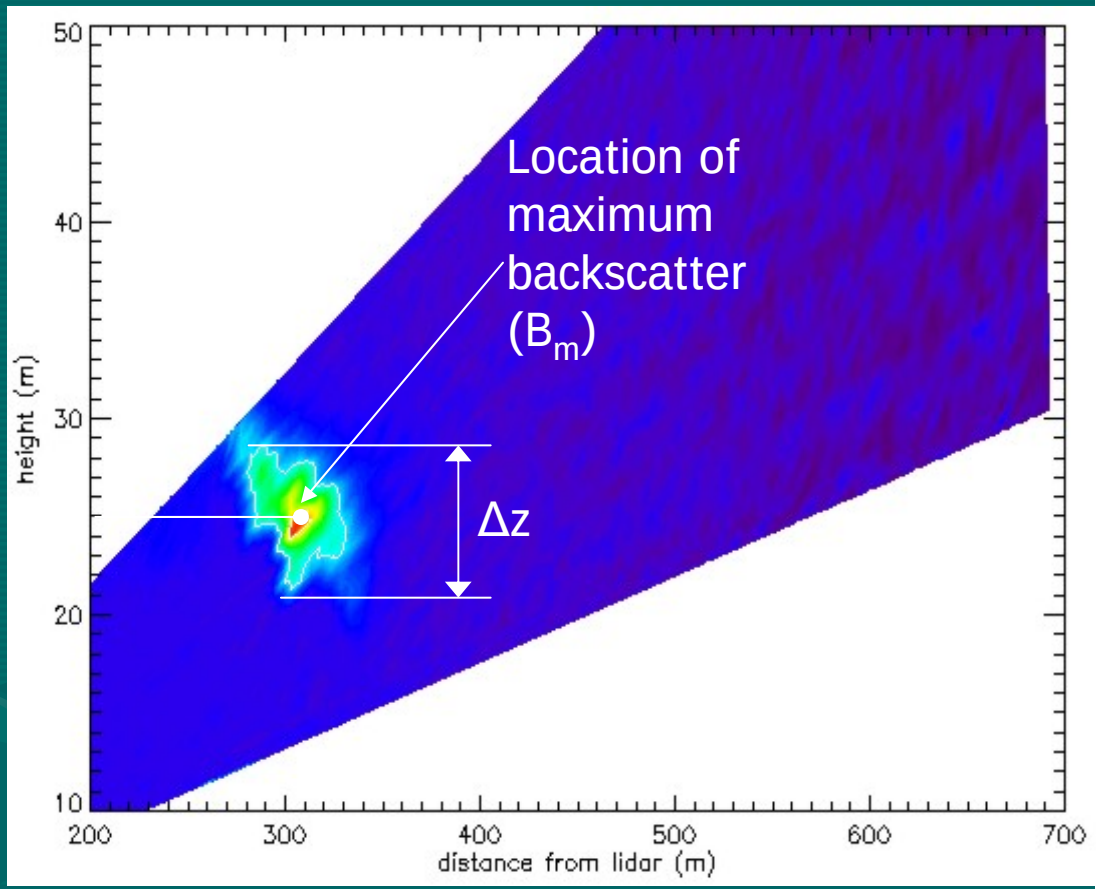

0.4
0.3
0.2
0.1
0
Concentraion (g/m3)
0
100
200
300
400
Time after release (seconds)
pass 1
pass 2
pass 3

Finding σ_s

$$\frac{\chi_e}{\chi_m} = e^{-\frac{z_e^2}{2\sigma_z^2}}$$

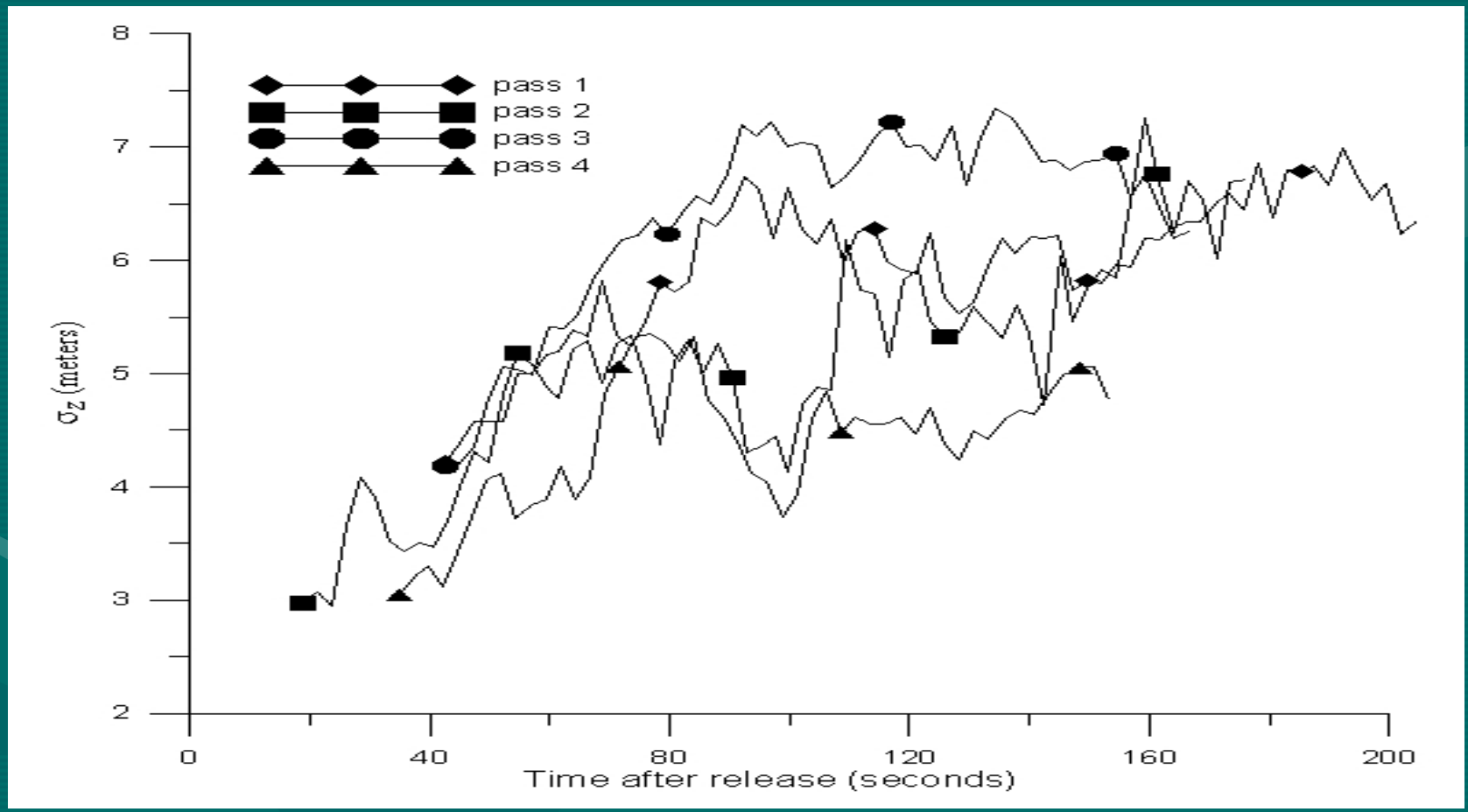
$$\alpha = \frac{B_M}{B_C}$$

$$\sigma_i^2 = \frac{\left(\frac{\Delta z}{2}\right)^2}{-2\ln\alpha}$$

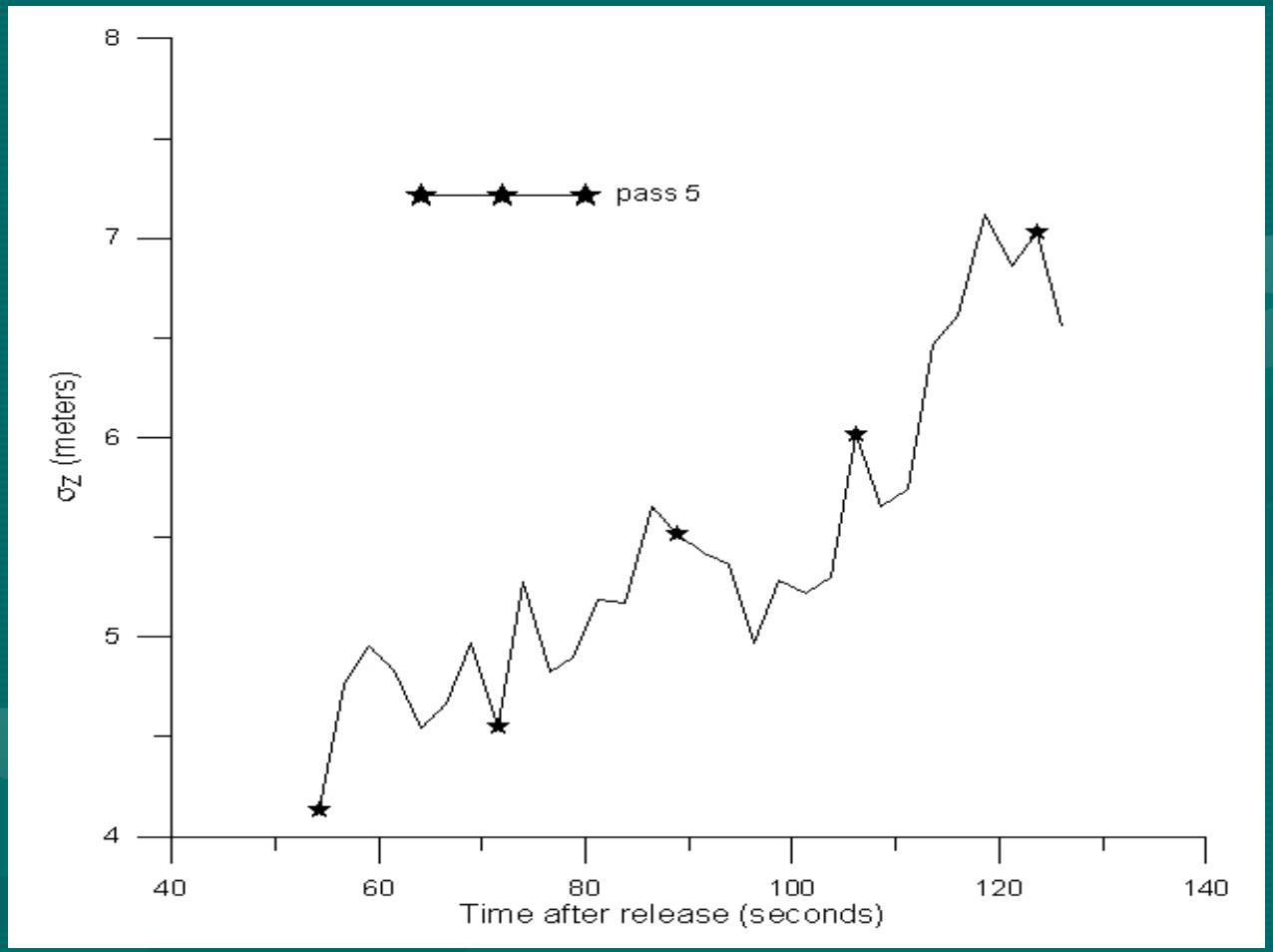


B_c = *backscatter value at plume edge*

Plume Dispersion, Stable Conditions



Plume Dispersion, Unstable Conditions



Conclusions

- Applications of very small droplets resulted in drifting plumes, which dispersed very slowly in stable air.
- About 40% of the active ingredient and 10% of the total mass sprayed remained air borne.
- During stable conditions the plume spread for 1-2 minutes and then stopped spreading. The initial spread was due to the turbulence caused by the aircraft.
- During unstable conditions, the plumes continued spreading indefinately due to atmospheric turbulence.